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RANGE OF CONTINUUM PROPERTIES AND THE UV/SOFT X-RAY CONNECTION FOR QUASARS

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1 Introduction

The peak of the emission from quasars is in the ultraviolet (UV) or the extreme UV. The big blue bump continuum feature is generally still rising at the high energy cutoff of IUE (Elvis et al. 1994). It is often interpreted as thermal emission either from an accretion disk (Malkan & Sargent 1982) or from optically thin free-free emission (Barvainis 1993). The soft X-ray excess is generally confined at low X-ray energy (<1.0 keV) and dominates the emission in the ROSAT PSPC (0.1-2 keV) band (Fiore et al. 1993). Its physical origin is still unknown with little spectral information available but the slope appears to be very steep suggesting that we are looking at the 'tip of the iceberg' with most of the flux being emitted in the unobserved extreme-UV band (EUV, i.e. 1000-100 angstroms). This leads to the tempting conclusion that the soft X-ray excess might be the high energy tail of the UV component, the big blue bump. However, a relation between the two components has yet to be conclusively demonstrated.

The combination of IUE and ROSAT data is a powerful one with which to constrain the UV–soft X-ray continuum of quasars. Observations for a few quasars have strengthened our belief of the connection between the emission in these two regions. However, with only a small number of heterogeneously selected objects, it is still not possible to demonstrate or understand any relation. To do this it is essential to obtain UV–soft X-ray data for a complete, well-defined quasar sample and gaining a systematic and unbiased picture of the soft X-ray/UV big blue bump in quasars.

2 Our Spectral Energy Distribution Program

This IUE program is part of a greater whole which aims to study the spectral energy distributions (SEDs) of a sample of $\sim$ 80 quasars covering a full range of properties and redshift. This will allow us not only to study the range but also the evolution of quasar SEDs over the population as a whole. Our goals include:

- Study the range in shape of the soft X-ray/UV/optical blue bump present in the quasar population.
- Study the evolution of the blue bump with redshift.
- Constrain the physical processes responsible for the blue bump via detailed modelling of individual objects and more general modelling of the larger sample.
- Study the X-ray and UV properties of associated absorbers in order to constrain the properties of the absorbing gas.
- Study the relation between optical/UV emission lines and the observed spectral energy distributions in the full sample in order to investigate the mechanisms responsible for generating the emission lines.

4 Scientific Results to date

4.1 Absorption

We have discovered that soft X-ray absorption is common in high luminosity, radio-loud quasars at high redshift. Since two of the three quasars are Giga-Hertz Peaked radio sources: compact due to confinement of their radio emission by dense gas, the X-ray absorption may also originate in this confining medium. Other possibilities include an associated warm absorber (see below) or geometric effects. The radio-quiet objects show less absorption and look similar to their low-redshift counterparts, indicating that the absorption in the radio-loud objects is intrinsic and possibly constitutes a significant difference between the two classes of object either due to orientation or the presence/absence of surrounding material.

We have confirmed in 3 separate cases: 3C212, 3C351, NGC5548; that the ultra-violet, associated, metal-line absorption lines originate in the same gas as the soft X-ray warm absorption. This is the first time that X-ray absorption has been linked to that at other wavelengths and opens up very exciting possibilities for study of absorption as the combination of ultraviolet and X-ray data allows us to place strong constraints on the physical conditions of the absorber. Our work so far indicates that the material is outflowing at ~ 1000 km s^{-1}, probably situated outside the broad emission line region ($\sim 10^{16} - 10^{18}$ cm) with highly ionisation ($U \sim 1 - 10$) and large column density ($N_H \sim 10^{21-22}$ cm^{-2}). It could be part of a wind blown off the surface of an accretion disk or part of a medium in between the broad and narrow emission line regions providing negligible eission, but significant absorption.

This connection between X-ray and UV absorbers may be the first step to understanding all associated absorption in quasars. For example the drammatic, broad absorption troughs, often extending up to ~ 0.1c, seen in 10% of radio quiet quasars, occur in objects which are unusually X-ray weak, perhaps due to absorption by the same medium.

4.2 Spectral Energy Distributions

The X-ray slope and optical to X-ray flux ratio are correlated in our PG sample. This correlation implies that a hard X-ray component is present in varying strengths. The X-ray slope is also correlated with a few emission lines properties , eg. [OIII] flux, Hβ FWHM. The cause of these correlations is not immediately apparent and they are being further investigated using a larger sample.

The IR-X-ray SEDs of a few, low-redshift quasars have been compared with accretion disk and free-free models for the blue bump component. Neither model matches the data in its simplest form. Modifications to the accretion disk model, such as the inclusion of an electron-scattering atmosphere, are able to match the data. The free-free model will have problems should the observed range of slopes in the optical-UV range be confirmed as intrinsic rather than the result of redenning or variability.

A more general test of accretion disk and free-free models has been made for a larger sample using colors to describe the IR–UV–X-ray SEDs of the quasars. We conclude here that the blue bump can be matched in shape and luminosity using modified black-body emission from a Kerr accretion disk, although the X-ray emission is not successfully reproduced.

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